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Sakaguchi

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(54) **WIRE**

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H01B 7/04 (2006.01)
(Continued)

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CPC ***H01B 7/04*** (2013.01); *H01B 7/0009* (2013.01); *H01B 13/02* (2013.01)

(58) **Field of Classification Search**
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(Continued)

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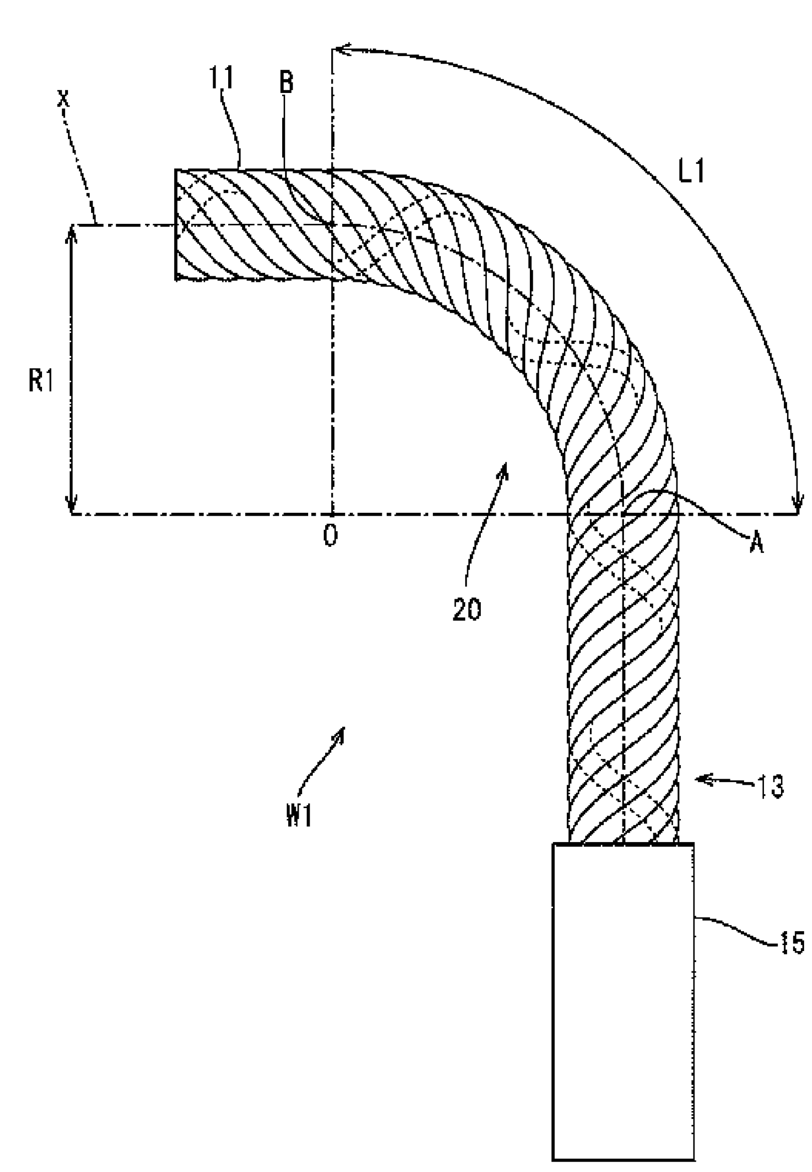
(57) **ABSTRACT**

A wire W**1** is a wire W**1** in which a plurality of strand conductors **11** are twisted at a predetermined twist pitch P**1** and which includes a bent portion **20** having a bent shape with a curvature K. A section length L**1** of the bent portion **20** is an integer multiple of the twist pitch P**1**.

3 Claims, 9 Drawing Sheets



(51) **Int. Cl.**
H01B 7/00 (2006.01)
H01B 13/02 (2006.01)

(58) **Field of Classification Search**
USPC 174/128.1
See application file for complete search history.

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FIG. 1

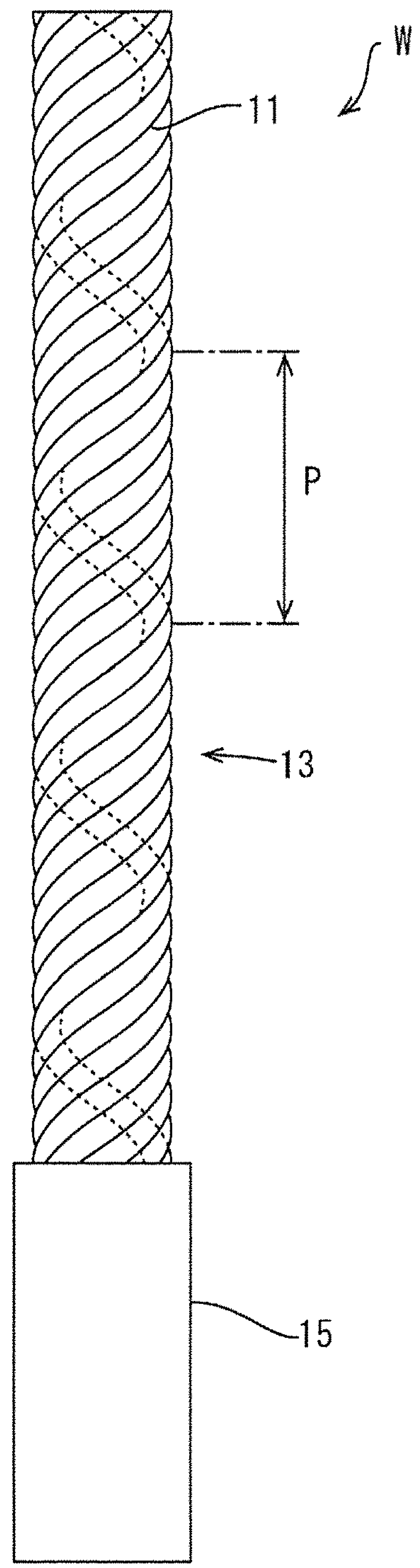


FIG. 2

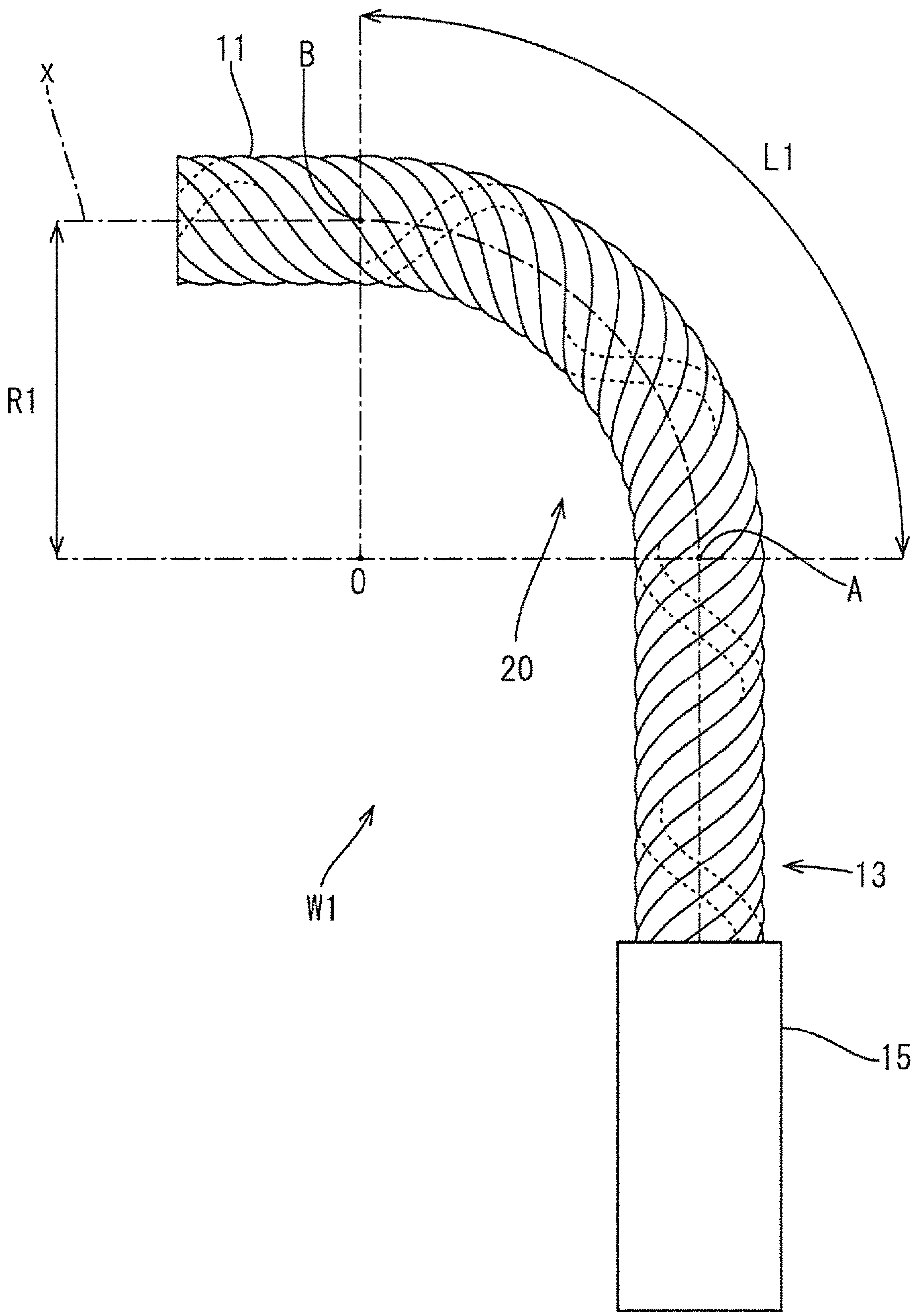
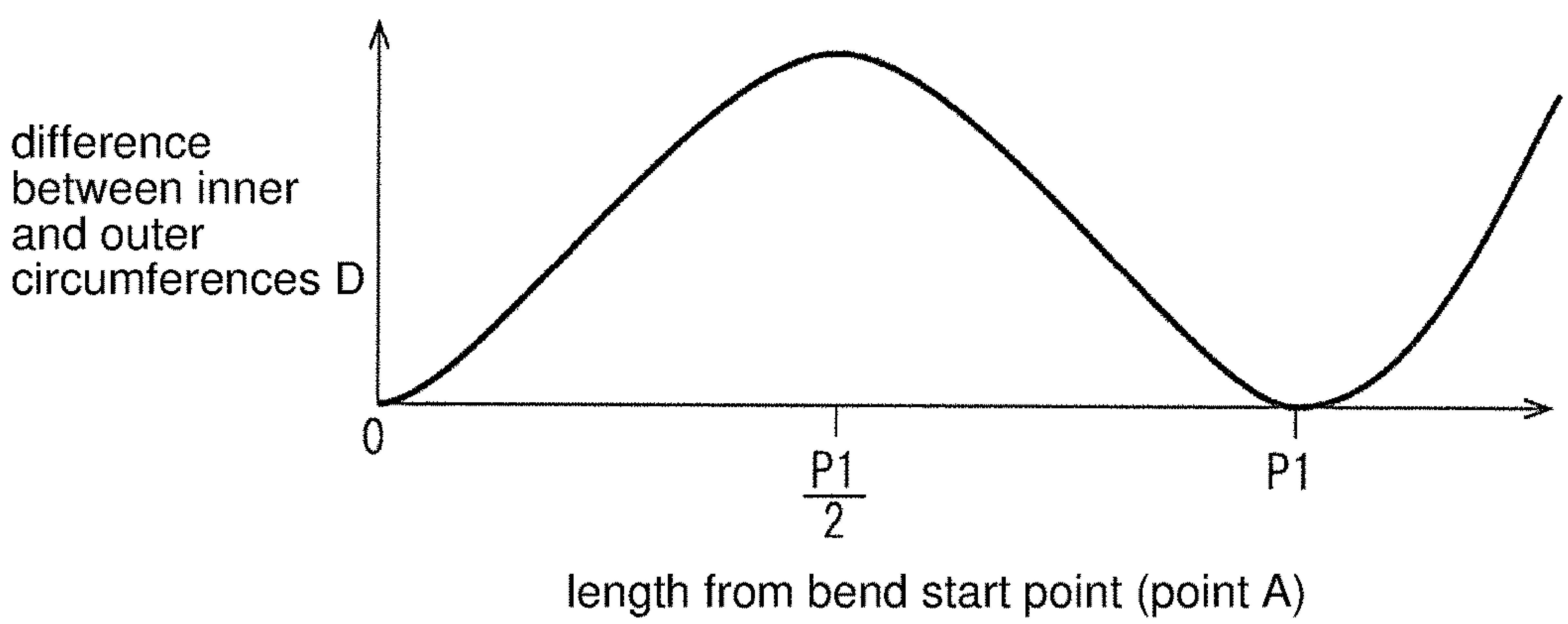


FIG. 3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0
P1/2
P1
length from bend start point (point A)

FIG. 4

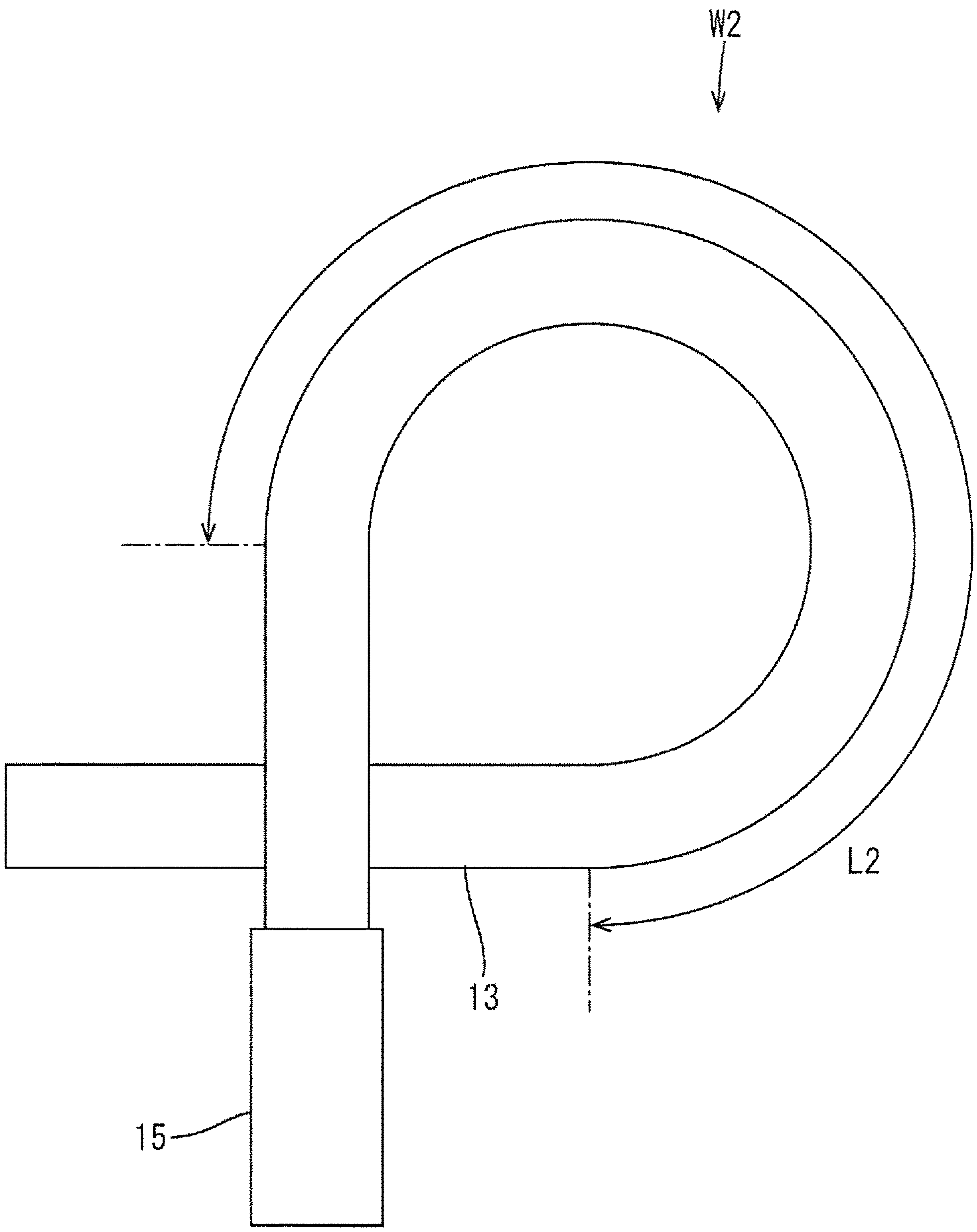


FIG. 5

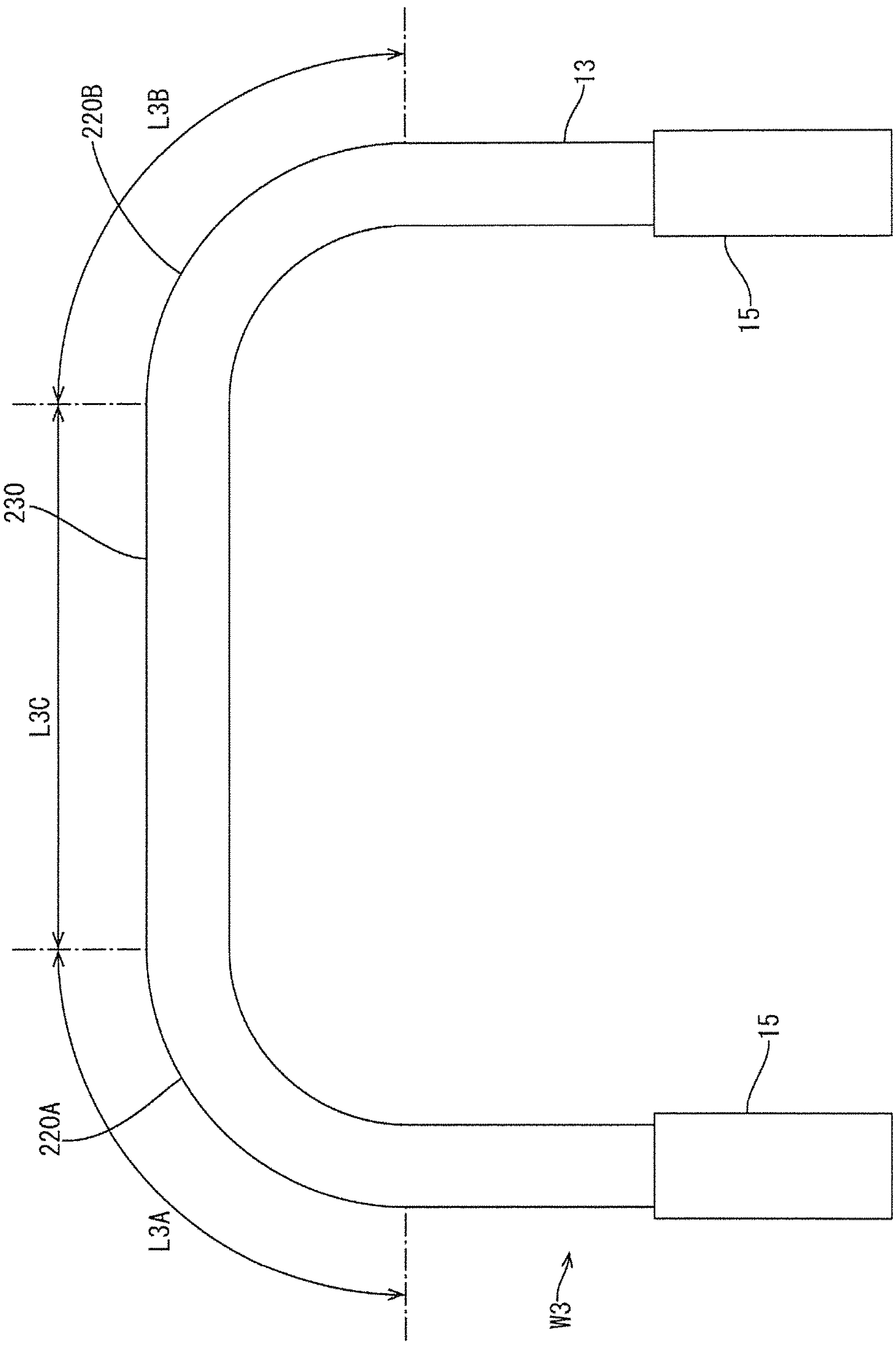


FIG. 6

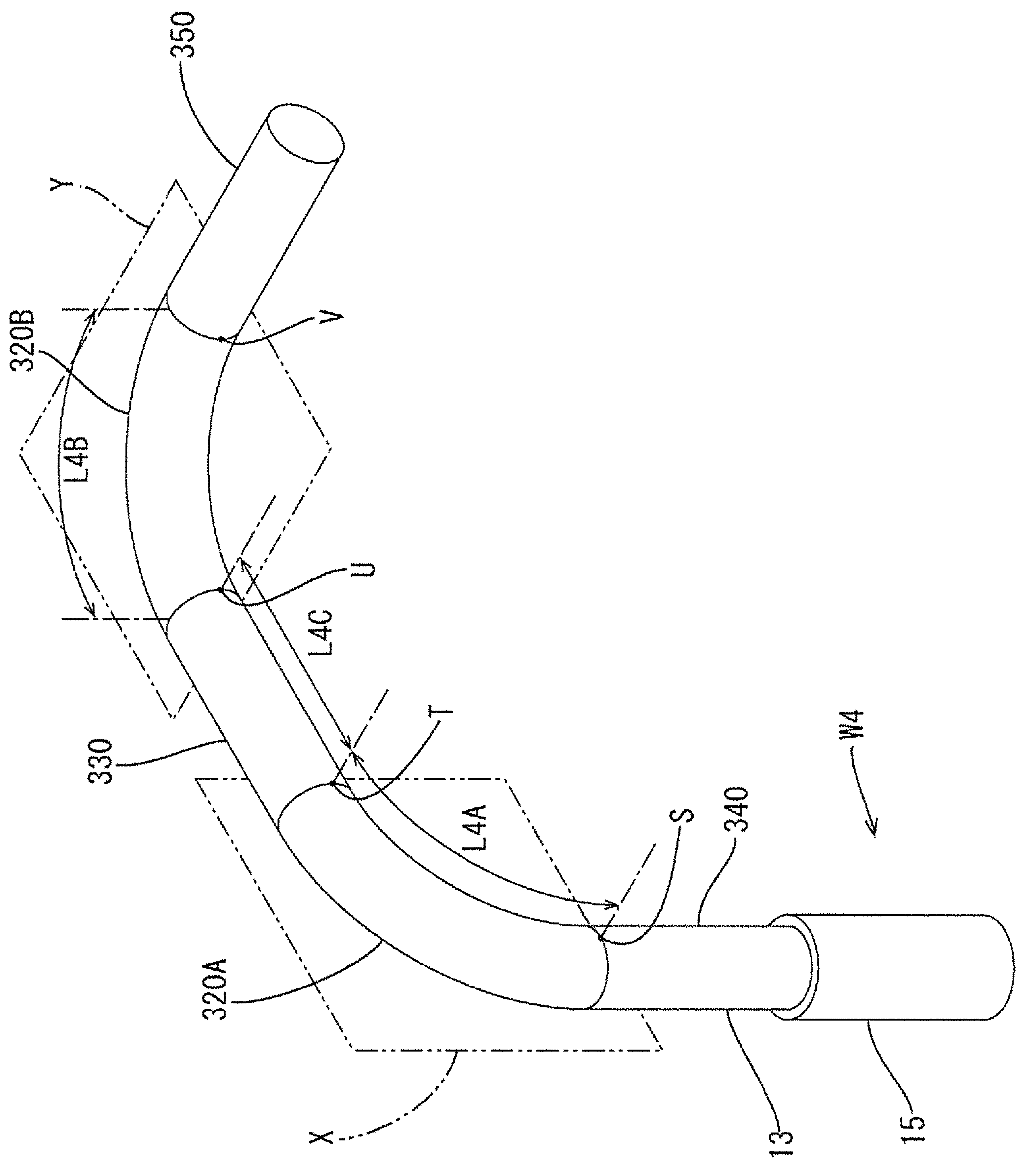


FIG. 7

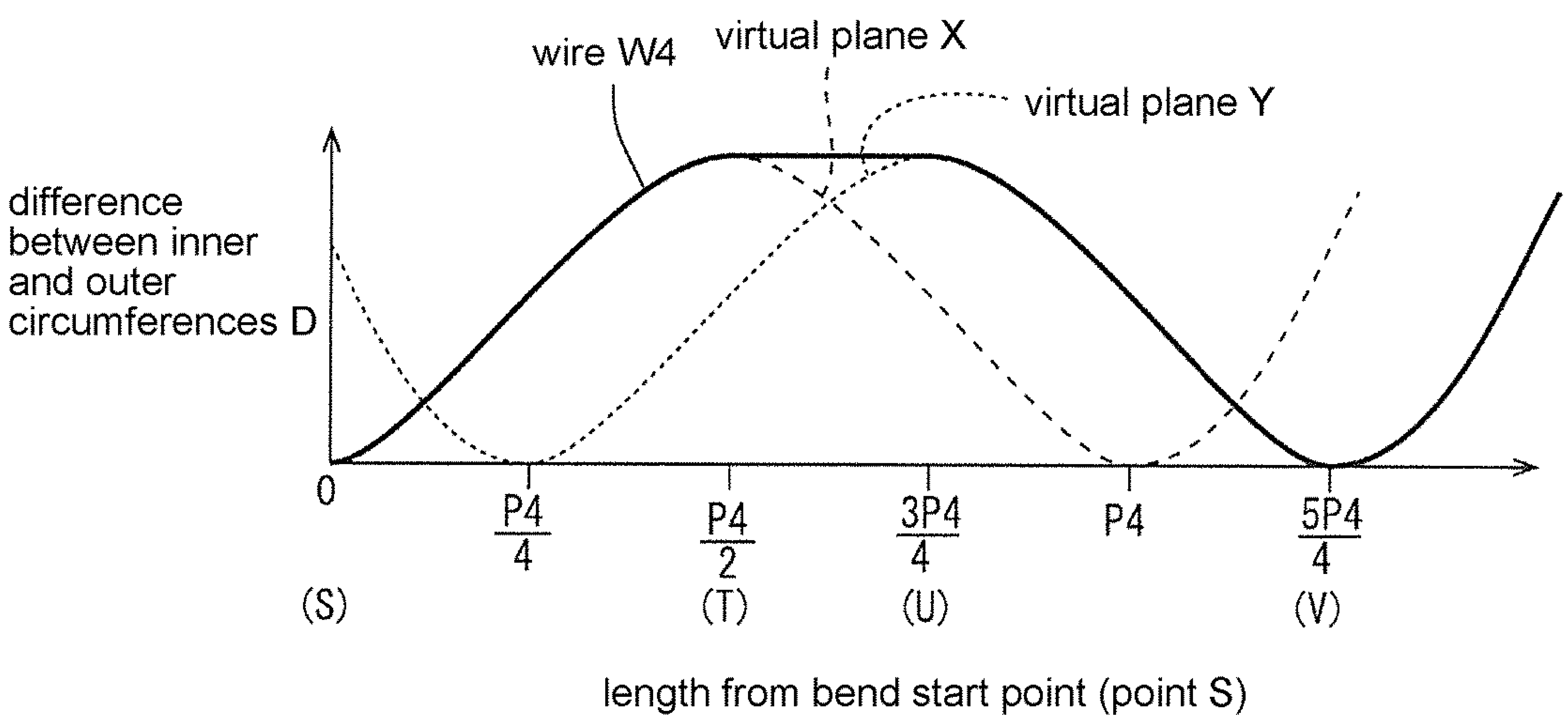

wire W4
virtual plane X
virtual plane Y
difference between inner and outer circumferences D
0
P4/4
P4/2
3P4/4
P4
5P4/4
(S)
(T)
(U)
(V)
length from bend start point (point S)

FIG. 8
PRIOR ART

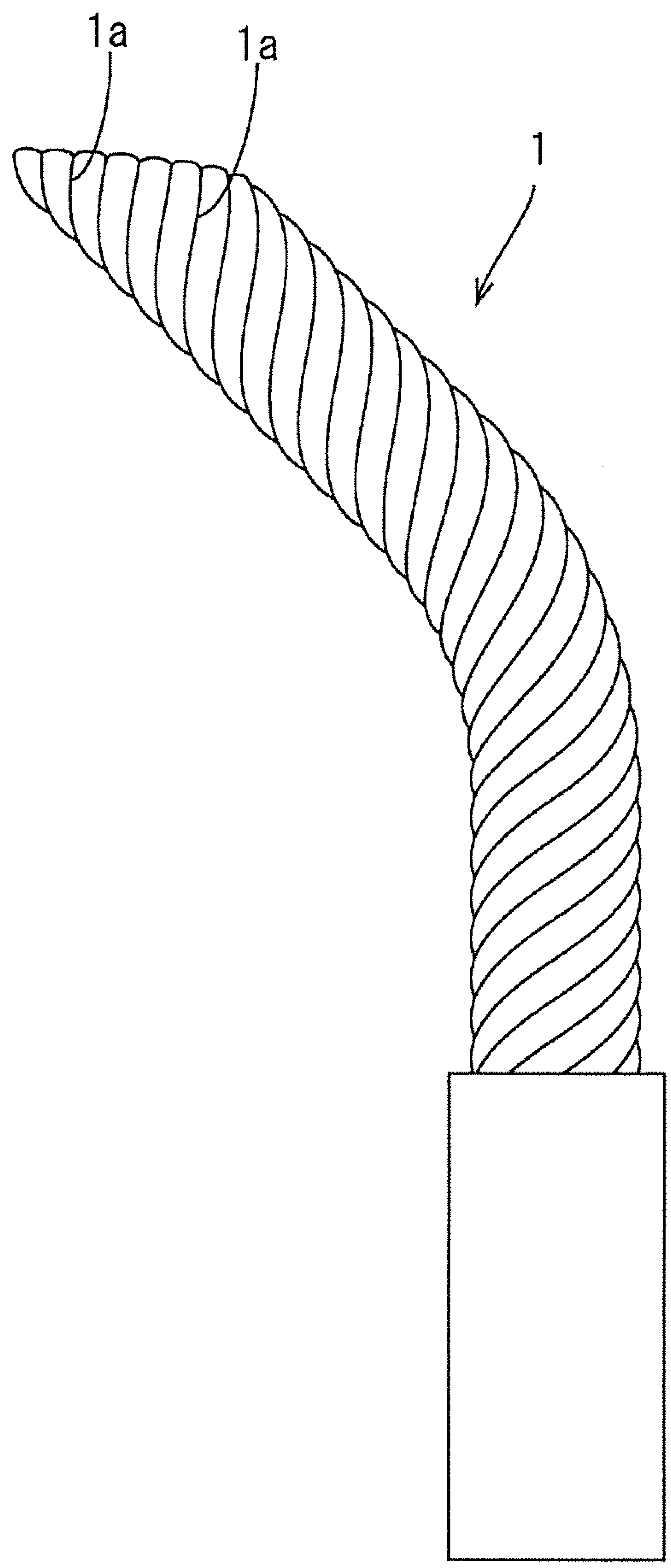
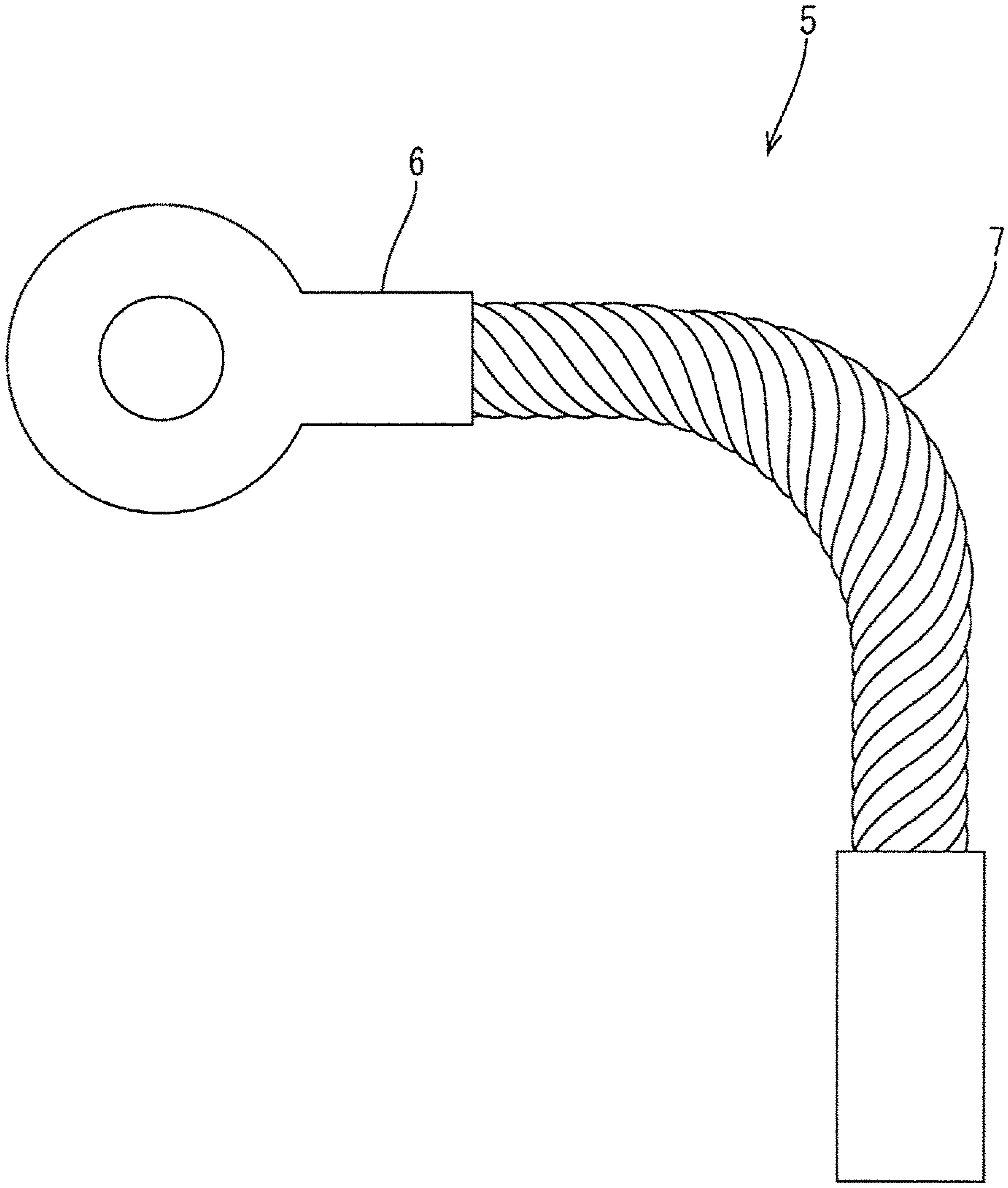


FIG. 9
PRIOR ART



WIRE

BACKGROUND

Field of the Invention

This specification relates to a wire.

Description of the Related Art

Conventional coated wires used for wiring of vehicles, electric and electronic devices and the like have a conductor coated with an insulator. A conductor of this wire generally is configured by twisting a plurality of metal strands. If a stranded conductor formed by twisting the strands in this way is bent, a length differs for each of the strands located on an inner peripheral side and an outer peripheral side in a bent portion. Thus, if an end of the stranded conductor is not fixed, end parts of respective strands **1***a* of a wire **1** are irregular, as shown in FIG. **8**. Further, if the end of the stranded conductor is fixed, such as by a terminal **6**, a bent portion **7** of a wire **5** bulges, as shown in FIG. **9**. If these shape abnormalities are corrected, the inherent flexibility of the stranded conductor is impaired.

Japanese Unexamined Patent Publication No. 2014-143217 attempts to improve the flexibility and bending resistance of the wire by adjusting a twist pitch and a strand diameter of the wire. However, in the configuration of Japanese Unexamined Patent Publication No. 2014-143217, cost may increase since a dedicated wire needs to be prepared to avoid shape abnormalities of a bent portion of the wire.

SUMMARY

This specification relates to a wire in which strand conductors are twisted at a predetermined twist pitch. The wire includes a bent portion having a bent shape with a predetermined curvature, and a section length of the bent portion is an integer multiple of the twist pitch. Accordingly since of all the strand conductors are equally distributed on inner and outer peripheral sides in the bent portion so that the route lengths of the respective strand conductors in the bent portion are equal. Therefore, the flexibility of the wire is not impaired and, even if an end of the wire is fixed, the bent portion does not bulge.

The above-described configuration with strand conductors twisted at a predetermined twist pitch and having a bent portion can be manufactured by being bent such that a section length of the bent portion is equal to an integer multiple of the twist pitch.

The wire may have a plurality of bent portions and a straight portion linearly connecting between the respective bent portions. In this configuration, the sum of section lengths of the respective bent portions and the sum of section lengths of the straight portions are both an integer multiple of the twist pitch According to this configuration, even in the wire including the straight portion in an intermediate part, total route lengths of the respective strand conductors in the plurality of bent portions are equal. Further, the twist pitch is maintained in the straight portion. Therefore, the flexibility of the wire is not impaired and, even if an end of the wire is fixed, the bent portion does not bulge.

As described above, the wire may be bent such that the sum of section lengths of the respective bent portions and the sum of section lengths of the straight portions are both an integer multiple of the twist pitch.

There may be two bent portions, and the section lengths of the two bent portions may be equal and half the integer multiple of the twist pitch.

Even in the wire that is U-shaped by the two bent portions and the straight portion therebetween, the route lengths of the respective strand conductors are equal by having this configuration.

According to the wire disclosed in this specification, it is possible to prevent an end part of the wire from becoming irregular and to prevent the conductor strands from bulging in the bent portion even if the wire is a stranded wire and includes the bent portion.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a front view of a wire before being bent in each embodiment.

FIG. **2** is a front view of a wire in a first embodiment.

FIG. **3** is a graph showing a wire pitch and a difference between inner and outer circumferences of strands.

FIG. **4** is a schematic front view of a wire in a second embodiment.

FIG. **5** is a schematic front view of a wire in a third embodiment.

FIG. **6** is a schematic perspective view of a wire in a fourth embodiment.

FIG. **7** is a graph showing a wire pitch and a difference between inner and outer circumferences of strands.

FIG. **8** is a front view of a conventional wire with a bent free end.

FIG. **9** is a front view of a conventional wire with a bent fixed end.

DETAILED DESCRIPTION

A wire W used in each embodiment is described with reference to FIG. **1**.

The wire W has a core **13** formed by twisting strand conductors **11** at a predetermined twist pitch P, and the core **13** is coated by an insulation coating **15**. The twist pitch P indicates a length by which the strand conductors **11** advance along an axial direction of the wire W by twisting rotation while making one turn. That is, the twist pitch P indicates a length of the wire W in a longitudinal direction required for the strand conductors **11** to rotate 360°.

First Embodiment

A wire W**1** of this embodiment is described with respect to FIGS. **2** and **3**. In this embodiment, as shown in FIG. **2**, the wire W is one type of the wire shown in FIG. **1** and has a bent portion **20** bent at a radius of curvature R**1**. The bent portion **20** is provided in a part where a core **13** formed by twisting strand conductors **11** at a twist pitch P**1** is exposed, and is bent such that a line along the wire W**1** between a point A (bend start point) and a point B (bend end point) forms an arc of approximately 90°. Note that the radius of curvature R**1** is a distance from a center axis x of the core **13** to a center of curvature O. Further, a curvature K**1** serving as an index of a bent state is defined as an inverse of the radius of curvature (K**1**=1/R**1**). That is, the wire W**1** has the bent portion **20** bent with the curvature K**1**.

A section length L**1** of the bent portion **20** indicates a length of a section where the wire W**1** is bent (length from the point A to the point B) as shown in FIG. **2**. More specifically, the section length L**1** is a length from the point A to the point B in a state before the bent portion **20** is bent (natural state) and a length of the bent portion **20** along the center axis x in the bent portion **20**. Note that the center axis x is an axis extending in an axial direction (longitudinal direction) of the wire W**1** passing through a center position in a radial direction of the core **13**.

In the bent portion **20**, the strand conductors **11** of the wire W**1** in a part outward of the center axis x extend along a longer route as compared to an unbent state, and the strand conductors **11** of the wire W**1** in a part inward of the center axis x extend along a shorter route as compared to the unbent state. As a result, the strand conductors **11** are lacking on the side outward of the center axis x, and the strand conductors **11** become redundant on the side inward of the center axis x. Due to such excesses and deficiencies of the respective strand conductors **11**, a difference D between inner and outer circumferences is present among the respective strand conductors **11**.

As each strand conductor **11** moves in the longitudinal direction thereof, the position of each strand conductor **11** with respect to the center axis x also moves according to twisting rotation (twist pitch P**1**). A value of an excess and deficiency dL of each strand conductor **11** in the bent portion **20** has periodicity with respect to the twist pitch P**1** by accumulating the excesses and deficiencies from the start point of the bent portion **20**. As a result, the difference D between inner and outer circumferences among the respective strand conductors **11** also has periodicity with respect to the twist pitch P**1**.

As shown in FIG. **3**, the difference D between inner and outer circumferences of each strand conductor **11** is largest when the length from the point A is P1/2 (half value of the twist pitch) and 0 when the length from the point A is the twist pitch P**1**. Since a difference D between inner and outer circumferences of the wire W**1** bent with the same curvature K**1** has periodicity with respect to the twist pitch P**1**, the difference D between inner and outer circumferences is 0 when the length from the point A is an integer multiple of the twist pitch P**1**. That is, the difference D between inner and outer circumferences of the bent portion **20** is 0 when the section length L**1** of the bent portion **20** is an integer multiple of the twist pitch P**1**.

When the difference D between inner and outer circumferences of the bent portion **20** is 0 as just described, the excess and deficiency dL of each strand conductor **11** in the bent portion **20** is also 0. That is, when the section length L**1** of the bent portion **20** is an integer multiple of the twist pitch P**1**, route lengths of the respective strand conductors **11** in the bent portion **20** become equal and end parts at the start points and the end points of the respective strand conductors having an equal route length are aligned by tensile forces of the respective strand conductors **11**. Further, when the section length L**1** of the bent portion **20** is an integer multiple of the twist pitch P**1**, all of the strand conductors **11** are distributed equally on inner and outer peripheral sides in the bent portion **20**.

As just described, if the wire W**1** is bent such that the section length L**1** of the bent portion **20** is an integer multiple of the twist pitch P**1**, the wire W**1** can be bent without the flexibility thereof being impaired. Further, if the section length L**1** of the bent portion **20** is an integer multiple of the twist pitch P**1**, the bent portion **20** does not bulge even if the end of the wire W**1** is fixed.

Second Embodiment

A wire W**2** with a bent portion **120** having a different shape is described using FIG. **4**. Note that the same components as in the first embodiment are denoted by the same reference signs and are not described. Further, each strand conductor **11** is not shown to simplify the drawing.

In this embodiment, as shown in FIG. **4**, the wire W**2** as one type of the wire shown in FIG. **1** includes the bent portion **120** having a bent shape with a curvature K**2**. The bent portion **120** is provided in a part where a core **13** formed by twisting strand conductors **11** at a twist pitch P**2** is exposed, and bent such that a line along the wire W**2** between a start point and an end point forms an arc of approximately 270°.

As in the first embodiment, when a section length L**2** of the bent portion **120** is an integer multiple of the twist pitch P**2**, a difference D between inner and outer circumferences of the bent portion **120** is 0. That is, when the section length L**2** of the bent portion **120** is an integer multiple of the twist pitch P**2**, route lengths of the respective strand conductors **11** in the bent portion **120** become equal and all of the strand conductors **11** are distributed equally on inner and outer peripheral sides in the bent portion **120**.

As just described, if the wire W**2** is bent such that the section length L**2** of the bent portion **120** is an integer multiple of the twist pitch P**2**, the wire W**2** can be bent without the flexibility thereof being impaired. Further, if the section length L**2** of the bent portion **120** is an integer multiple of the twist pitch P**2**, the bent portion **120** does not bulge even if the end of the wire W**2** is fixed.

Third Embodiment

A wire W**3** with bent portions **220** having a different shape is described using FIG. **5**. Note that the same components as in the first embodiment are denoted by the same reference signs and are not described. Further, each strand conductor **11** is not shown to simplify the drawing.

In this embodiment, as shown in FIG. **5**, the wire W**3** as one type of the wire shown in FIG. **1** includes two bent portions **220** having a bent shape with a curvature K**3** and a straight portion **230** linearly connecting between the respective bent portions **220**. The bent portions **220** and the straight portion **230** are provided in a part where a core **13** formed by twisting strand conductors **11** at a twist pitch P**3** is exposed. Each bent portion **220** is bent with the same curvature K**3** such that a line along the wire W**3** between a bend start point and a bend end point of the bent portion **220** forms an arc of approximately 90°. The straight portion **230** is provided between the respective bent portions **220** and the respective bent portions **220** and the straight portion **230** are located on the same plane. Thus, the wire W is bent into a U shape.

A section length L**3**A of the first bent portion **220**A is ½ of the twist pitch P**3** and a section length L**3**B of the second bent portion **220**B is also ½ of the twist pitch P**3**. Further, a section length L**3**C of the straight portion **230** is an integer multiple of the twist pitch P**3**. As shown in FIG. **3**, the difference D between inner and outer circumferences of each strand conductor **11** is largest when the length from the bend start point is a half value of the twist pitch P. Thus, the difference D between inner and outer circumferences of the wire W**3** is largest when the length is ½ of the twist pitch P**3**.

The section length L**3**A of the first bent portion **220**A is ½ of the twist pitch P**3**. Thus, the difference D between inner and outer circumferences at the bend end point of the one bent portion **220**A is largest. The difference D between inner and outer circumferences and an excess and deficiency dL of each strand conductor **11** are maintained without any deviation also in the straight portion **230** since the section length

L3C of the twist pitch **230** is an integer multiple of the twist pitch P**3**. As just described, the bend start point of the second bent portion **220**B is reached with the excesses and deficiencies dL of the strand conductors **11** and the difference D between inner and outer circumferences caused in the first bent portion **220**A maintained.

The section length L3B of the second bent portion **220**B is ½ of the twist pitch P**3** and the sum of the section lengths L3A, L3B is an integer multiple of the twist pitch P**3**. Further, each bent portion **220** is bent with the same curvature K**3**, and the excesses and deficiencies dL of the respective strand conductors **11** and the difference D between inner and outer circumferences caused at the same length are equal. Thus, the excesses and deficiencies dL of the strand conductors **11** and the difference D between inner and outer circumferences caused in the second bent portion **220**B and the excesses and deficiencies dL of the strand conductors **11** and the difference D between inner and outer circumferences maintained in the straight portion **230** cancel out each other and the difference D between inner and outer circumferences at the end point of the second bent portion **220**B is 0.

That is, when the sum of the section lengths L3A, L3B of a plurality of the bent portions **220**A, **220**B is an integer multiple of the twist pitch P3, route lengths of the respective strand conductors **11** in the case of summing the respective bent portions **220** become equal. Further, by setting the section length L3C of the straight portion **230** at an integer multiple of the twist pitch P3, the bend start point of the second bent portion **220**B is reached with the excesses and deficiencies dL of the strand conductors **11** and the difference D between inner and outer circumferences caused in the first bent portion **220**A maintained.

As described above, according to the third embodiment, the wire W**3** has strand conductors **11** twisted at the predetermined twist pitch P**3** and includes the bent portions **220** having a bent shape with the predetermined curvature K3 and the straight portion **230** linearly connecting between the respective bent portions **220**. Additionally, the sum of the section lengths L3A, L3B of the bent portions **220** and the sum of the section length(s) of the straight portion(s) **230** are both an integer multiple of the twist pitch P**3**.

As just described, if the wire W3 includes the straight portion **230** between the bent portions **220**, the wire W3 can be bent without the flexibility thereof being impaired. Further, the bent portion **220** does not bulge even if the end of the wire W3 is fixed.

Fourth Embodiment

A wire W**4** with bent portions **320** having a different shape is described using FIGS. **6** and **7**. Note that the same components as in the first embodiment are denoted by the same reference signs and not described. Further, each strand conductor **11** is not shown to simplify the drawing.

In this embodiment, as shown in FIG. **6**, the wire W**4** as one type of the wire shown in FIG. **1** includes two bent portions **320** having a bent shape with a curvature K4 and a straight portion **330** linearly connecting between the respective bent portions **320**. The bent portions **320** and the straight portion **330** are provided in a part where a core **13** formed by twisting strand conductors **11** at a twist pitch P**4** is exposed.

Each bent portion **320** is bent with the same curvature K**4** such that a line along the wire W**4** between a bend start point S, U and a bend end point T, V of the bent portion **320** forms an arc of approximately 90°. The straight portion **330** is provided between the bent portions **320**. A part of the wire

W before a part where the bent portions **320** are provided (start point S) is a straight front end part **340**, and a part behind the part where the bent portions **320** are provided (end point V) is a straight rear end part **350**. The wire W**4** is bent three-dimensionally such that the front end part **340** and the rear end part **350** are twisted with respect to each other.

A center axis of a first bent portion **320**A is disposed on a virtual plane X defined by a center axis of the front end part **340** and a center axis of the straight portion **330**. Further, a center axis of a second bent portion **320**B is disposed on a virtual plane Y defined by the center axis of the straight portion **330** and a center axis of the rear end part **350**. The virtual planes X and Y are perpendicular.

A section length L**4**A of the first bent portion **320**A is ½ of the twist pitch P**4** and a section length L**4**B of the second bent portion **320**B is also ½ of the twist pitch P**4**. That is, the sum of the section lengths L4A, L4B is an integer multiple of the twist pitch P**4**. Further, a section length L**4**C of the straight portion **330** is ¼ of the twist pitch P**4**.

As shown in FIGS. **6** and **7**, a difference D between inner and outer circumferences at the bend end point V (boundary position between the second bent portion **320**B and the rear end part **350**) is 0 in the wire W**4**. Note that, in FIG. **7**, relationships between the length from the bend start position S and the difference D between inner and outer circumferences of a wire having a center axis located on the virtual plane X and bent with the curvature K**4** and a wire having a center axis located on the virtual plane Y and bent with the curvature K**4** are drawn in broken lines. Since the virtual planes X and Y are perpendicular and the wires are bent with the same curvature K**4**, relationships with the difference D between inner and outer circumferences and the like due to bending also move parallel in a length direction. Further, a relationship between the length of the wire W**4** from the bend start point S and the difference D between inner and outer circumferences is drawn in a solid line.

The section length L**4**A of the first bent portion **320**A on the virtual plane X is ½ of the twist pitch P**4** (P**4**/2), and the difference D between inner and outer circumferences of the first bent portion **320**A at the end point T is largest. Then, the difference D between inner and outer circumferences at the start point U of the second bent portion **320**B having the center axis disposed on the virtual plane Y perpendicular to the virtual plane X is made equal to the difference D between inner and outer circumferences at the end point T of the first bent portion **320**A. That is, the difference D between inner and outer circumferences at the start point U of the other bent portion **320**B is set largest.

A case is described where the difference D between inner and outer circumferences at the start point U of the second bent portion **320**B becomes equal to the difference D between inner and outer circumferences at the end point T of the first bent portion **320**A as just described. In the wire having the center axis on the virtual plane Y, the difference D between inner and outer circumferences is largest at a position where the length from the bend start point S is ¾ of the twist pitch P4 (3P4/4). Thus, if the position where the length from the bend start point S is ¾ of the twist pitch P4 (3P**4**/4) is the start point U of the second bent portion **320**B, the difference D between inner and outer circumferences at the start point U of the second bent portion **320**B becomes equal to the difference D between inner and outer circumferences at the end point T of the first bent portion **320**A.

The section length L4C of the straight portion **330** for setting such a start point U of the second bent portion **320**B is described. The end point T of the first bent portion **320**A is a position where the length from the bend start point S is ½ of the twist pitch **P4** (**P4**/2). The start point U of the second bent portion **320**B is a position where the length from the bend start point S is ¾ of the twist pitch **P4** (3**P4**/4). Thus, the section length L**4**C of the straight portion **330** may be set as a difference between these lengths and is, specifically, ¼ of the twist pitch P**4**.

Further, the sum of the section lengths L**4**A, L**4**B of the bent portions **320**A, **320**B is an integer multiple of the twist pitch P**4** and each bent portion **320** is bent with the same curvature K**4**. Thus, if the difference D between inner and outer circumferences at the start point U of the second bent portion **320**B becomes equal to the difference D between inner and outer circumferences at the end point T of the first bent portion **320**A, the difference D between inner and outer circumferences and excesses and deficiencies dL of the respective strand conductors **11** caused in the first bent portion **320**A and the difference D between inner and outer circumferences and the excesses and deficiencies dL of the respective strand conductors **11** caused in the second bent portion **320**B cancel out each other as in the third embodiment.

That is, when the sum of the section length L**4**A, L**4**B of the two bent portions **320**A, **320**B is an integer multiple of the twist pitch P**4**, route lengths of the respective strand conductors **11** in the case of summing the respective bent portions **320** become equal. Further, by setting the virtual planes X, Y, where the bent portions **320**A, **320**B are disposed, perpendicular to each other and setting the section length L**4**C of the straight portion **330** at an integer multiple of ¼ of the twist pitch P**4**, the start point U of the other bent portion **320**B is reached with the excesses and deficiencies dL of the strand conductors **11** and the difference D between inner and outer circumferences caused in the one bent portion **320**A maintained.

As described above, according to the fourth embodiment, the wire W**4** has strand conductors **11** twisted at the predetermined twist pitch P**4** and includes the two bent portions **320** having a bent shape with the predetermined curvature K**4** and the straight portion **330** linearly connecting between the respective bent portions **320**. The virtual planes X, Y where the center axes of the respective bent portions **320**A, **320**B are disposed are perpendicular. Additionally, the sum of the section lengths L**4**A, L**4**B of the respective bent portions **320** is set at an integer multiple of the twist pitch P**3** and the section length L**4**C of the straight portion **330** is set at an integer multiple of ¼ of the twist pitch P**4**.

As just described, if the wire W**4** is bent three-dimensionally and includes the straight portion **330** between the bent portions **320**, the wire W**4** can be bent without the flexibility thereof being impaired. Further, the bent portion **320** does not bulge even if the end of the wire W**4** is fixed.

In a method for bending the wire W**4** in which the plurality of strand conductors **11** are twisted at the predetermined twist pitch P**4**, the wire W**4** includes the two bent portions **320** and the straight portion **330** linearly connecting between the respective bent portions **320**. The wire W**4** is bent such that the section length of the straight portion **330** is an integer multiple of ¼ of the twist pitch P**4**, whereas the two bent portions **320**A, **320**B are bent with the same curvature K**4** and the center axes thereof are respectively disposed on the perpendicular virtual planes X, Y. Additionally, the sum of the section lengths L**4**A, L**4**B of these two bent portions **320** is an integer multiple of the twist pitch P**4**.

Other Embodiment

The invention disclosed by this specification is not limited to the above described and illustrated embodiments. For example, the following modes are also included.

Although the bent portion **20**, **120**, **220**, **320** is provided at the position where the insulation coating **15** is stripped to expose the core **13** in the first to fourth embodiments, the bent portion may be coated with the insulation coating **15**.

Although the bent portion **20** is bent substantially at 90° in the first embodiment, the bent portion may be bent at a different angle.

Although the wire W**3** includes two bent portions **220** in the third embodiment, the wire may include three or more bent portions.

Although each bent portion **220**, **320** is bent substantially at 90° in the third and fourth embodiments, the bent portion may be bent at a different angle. For example, one bent portion may be bent at 45° and the other bent portion may be bent at 135°. Further, the section lengths of the bent portions may be different.

LIST OF REFERENCE SIGNS

11 . . . strand conductor
13 . . . core
15 . . . insulation coating
20, **120**, **220**(A, B), **320**(A, B) . . . bent portion
230, **330** . . . straight portion
340 . . . front end part
350 . . . rear end part
W, W**1**, W**2**, W**3**, W**4** . . . wire
L, L**1**, L**2**, L**3**A, L**3**B, L**3**C, L**4**A, L**4**B, L**4**C . . . section length
P, P**1**, P**2**, P**3**, P**4** . . . twist pitch
R**1** . . . radius of curvature
K**1**, K**2**, K**3**, K**4** . . . curvature
dL . . . excess and deficiency
D . . . difference between inner and outer circumferences
X, Y . . . virtual plane

The invention claimed is:

1. A wire in which a plurality of strand conductors are twisted at a predetermined twist pitch, the wire including a bent portion having a bent shape with a predetermined curvature in a part, wherein:
a section length of the bent portion is an integer multiple of the twist pitch.

2. A wire in which a plurality of strand conductors are twisted at a predetermined twist pitch, the wire including a plurality of bent portions and a straight portion linearly connecting between the respective bent portions, wherein:
the sum of section lengths of the respective bent portions and the sum of section lengths of the straight portions are both an integer multiple of the twist pitch.

3. The wire of claim **2**, wherein:
the plurality of bent portions comprise first and second bent portions; and
the section lengths of the first and second bent portions are equal and each is half the integer multiple of the twist pitch.

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